Internal assessment criteria

General information

The method of assessment used for internal assessment is criterion-related. That is to say, the method of assessment judges each student in relation to identified assessment criteria and not in relation to the work of other students.

The internal assessment component in all group 4 courses is assessed according to sets of assessment criteria and achievement level descriptors. The internal assessment criteria are for the use of teachers.

- For each assessment criterion, there are a number of descriptors that each describes a specific level of achievement.
- The descriptors concentrate on positive achievement, although for the lower levels failure to achieve may be included in the description.

Using the internal assessment criteria

Teachers should judge the internal assessment exercise against the descriptors for each criterion. The same internal assessment criteria are used for both SL and HL.

- The aim is to find, for each criterion, the descriptor that conveys most adequately the achievement level attained by the student. The process, therefore, is one of approximation. In the light of any one criterion, a student's work may contain features denoted by a high achievement level descriptor combined with features appropriate to a lower one. A professional judgment should be made in identifying the descriptor that approximates most closely to the work.
- Having scrutinized the work to be assessed, the descriptors for each criterion should be read, starting with level 0, until one is reached that describes an achievement level that the work being assessed does not match as well as the previous level. The work is, therefore, best described by the preceding achievement level descriptor and this level should be recorded. Only whole numbers should be used, not partial points such as fractions or decimals.
- The highest descriptors do not imply faultless performance and moderators and teachers should not hesitate to use the extremes, including zero, if they are appropriate descriptions of the work being assessed.
- Descriptors should not be considered as marks or percentages, although the descriptor levels are ultimately added together to obtain a total. It should not be assumed that there are other arithmetical relationships; for example, a level 2 performance is not necessarily twice as good as a level 1 performance.
- A student who attains a particular achievement level in relation to one criterion will not necessarily attain similar achievement levels in relation to the others. It should not be assumed that the overall assessment of the students will produce any particular distribution of scores.
- The assessment criteria should be available to students at all times.

Criteria and aspects

There are five assessment criteria that are used to assess the work of both SL and HL students.

- Design—D
- Data collection and processing—DCP
- Conclusion and evaluation—CE
- Manipulative skills—MS
- Personal skills—PS

The first three criteria—design (D), data collection and processing (DCP) and conclusion and evaluation (CE)—are each assessed twice.

Manipulative skills (MS) is assessed summatively over the whole course and the assessment should be based on a wide range of manipulative skills.

Personal skills (PS) is assessed once only and this will be during the group 4 project.

Each of the assessment criteria can be separated into three **aspects** as shown in the following sections. Descriptions are provided to indicate what is expected in order to meet the requirements of a given aspect **completely (c)** and **partially (p)**. A description is also given for circumstances in which the requirements are not satisfied, **not at all (n)**.

A **“complete”** is awarded 2 marks, a **“partial”** 1 mark and a **“not at all”** 0 marks.

The maximum mark for each criterion is 6 (representing three “completes”).

D	2 = 12
DCP	2 = 12
CE	2 = 12
MS	1 = 6
PS	1 = 6

This makes a total mark out of 48.

The marks for each of the criteria are added together to determine the final mark out of 48 for the IA component. This is then scaled at IBCA to give a total out of 24%.

General regulations and procedures relating to IA can be found in the Vade Mecum for the year in which the IA is being submitted.

Design

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Defining the problem and selecting variables	Controlling variables	Developing a method for collection of data
Complete/2	Formulates a focused problem/research question and identifies the relevant variables.	Designs a method for the effective control of the variables.	Develops a method that allows for the collection of sufficient relevant data.
Partial/1	Formulates a problem/research question that is incomplete **or** identifies only some relevant variables.	Designs a method that makes some attempt to control the variables.	Develops a method that allows for the collection of insufficient relevant data.
Not at all/0	Does not identify a problem/research question **and** does not identify any relevant variables.	Designs a method that does not control the variables.	Develops a method that does not allow for any relevant data to be collected.

Data collection and processing

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Recording raw data	Processing raw data	Presenting processed data
Complete/2	Records appropriate quantitative and associated qualitative raw data, including units and uncertainties where relevant.	Processes the quantitative raw data correctly.	Presents processed data appropriately and, where relevant, includes errors and uncertainties.
Partial/1	Records appropriate quantitative and associated qualitative raw data, but with some mistakes or omissions.	Processes quantitative raw data, but with some mistakes and/or omissions.	Presents processed data appropriately, but with some mistakes and/or omissions.
Not at all/0	Does not record any appropriate quantitative raw data **or** raw data is incomprehensible.	No processing of quantitative raw data is carried out **or** major mistakes are made in processing.	Presents processed data inappropriately **or** incomprehensibly.

Conclusion and evaluation

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Concluding	Evaluating procedure(s)	Improving the investigation
Complete/2	States a conclusion, with justification, based on a reasonable interpretation of the data.	Evaluates weaknesses and limitations.	Suggests realistic improvements in respect of identified weaknesses and limitations.
Partial/1	States a conclusion based on a reasonable interpretation of the data.	Identifies some weaknesses and limitations, but the evaluation is weak or missing.	Suggests only superficial improvements.
Not at all/0	States no conclusion **or** the conclusion is based on an unreasonable interpretation of the data.	Identifies irrelevant weaknesses and limitations.	Suggests unrealistic improvements.

Manipulative skills (assessed summatively)

This criterion addresses objective 5.

Levels/marks	Aspect 1	Aspect 2	Aspect 3
	Following instructions*	Carrying out techniques	Working safely
Complete/2	Follows instructions accurately, adapting to new circumstances (seeking assistance when required).	Competent and methodical in the use of a range of techniques and equipment.	Pays attention to safety issues.
Partial/1	Follows instructions but requires assistance.	Usually competent and methodical in the use of a range of techniques and equipment.	Usually pays attention to safety issues.
Not at all/0	Rarely follows instructions **or** requires constant supervision.	Rarely competent and methodical in the use of a range of techniques and equipment.	Rarely pays attention to safety issues.

*Instructions may be in a variety of forms: oral, written worksheets, diagrams, photographs, videos, flow charts, audio tapes, models, computer programs, and so on, and need not originate from the teacher.

See "The group 4 project" section for the personal skills criterion.

Clarifications of the IA criteria

Design

Aspect 1: defining the problem and selecting variables

It is essential that teachers give an open-ended problem to investigate, where there are several independent variables from which a student could choose one that provides a suitable basis for the investigation. This should ensure that a range of plans will be formulated by students and that there is sufficient scope to identify both independent and controlled variables.

Although the general aim of the investigation may be given by the teacher, students must identify a focused problem or specific research question. Commonly, students will do this by modifying the general aim provided and indicating the variable(s) chosen for investigation.

The teacher may suggest the general research question only. Asking students to investigate some property of a plant's cells, where no variables are given, would be an acceptable teacher prompt. This could be focused by the student as follows: "Does the cyclosis of chloroplasts in Elodea leaf cells vary with light intensity?"

Alternatively, the teacher may suggest the general research question and specify the dependent variable. An example of such a teacher prompt would be to ask the student to investigate the effect of a factor that influences enzyme activity. This could then be focused by the student as follows: "Does ethanol concentration affect the activity of bovine catalase?" It is not sufficient for the student merely to restate the research question provided by the teacher.

Variables are factors that can be measured and/or controlled. Independent variables are those that are manipulated, and the result of this manipulation leads to the measurement of the dependent variable. A controlled variable is one that should be held constant so as not to obscure the effects of the independent variable on the dependent variable.

The variables need to be explicitly identified by the student as the dependent (measured), independent (manipulated) and controlled variables (constants). Relevant variables are those that can reasonably be expected to affect the outcome. For example, in the investigation "How does the speed of movement of chloroplasts in Elodea cells vary with light intensity?", the student must state clearly that the independent variable is the light intensity and the dependent variable is the speed of movement. Relevant controlled variables would include temperature, preparation of Elodea cells, sample size and light quality (wavelength).

Students should **not** be:

- given a focused research question
- told the outcome of the investigation
- told which independent variable to select
- told which variables to hold constant.

Aspect 2: controlling variables

"Control of variables" refers to the manipulation of the independent variable and the attempt to maintain the controlled variables at a constant value. The method should include explicit reference to how the control of variables is achieved. If the control of variables is not practically possible, some effort should be made to monitor the variable(s).

A standard measurement technique may be used as part of a wider investigation but it should not be the focus of that investigation. Students should be assessed on their individual design of the wider investigation. If a standard measurement technique is used, it should be referenced. For example, while planning an investigation to study the effect of light wavelength on the rate of photosynthesis in Cabomba, the student may have adapted a method to measure the rate of photosynthesis taken from a textbook. A standard reference would then be expected as a footnote, for example, "Freeland, PW (1985) Problems in Practical Advanced Level Biology, Hodder and Stoughton." Or the student may adapt a general protocol provided by a teacher in a previous investigation. The reference may appear as: Michigan, J (2007) "Studying the rate of photosynthesis" worksheet.

Students should **not** be told:

- which apparatus to select
- the experimental method.

Aspect 3: developing a method for collection of data

The definition of "sufficient relevant data" depends on the context. The planned investigation should anticipate the collection of sufficient data so that the aim or research question can be suitably addressed and an evaluation of the reliability of the data can be made.

If error analysis involving the calculation of standard deviation is to be carried out, then a sample size of at least five is needed. The data range and amount of data in that range are also important. For example, when trying to determine the optimum pH of an enzyme, using a range of pH values between 6 and 8 would be insufficient. Using a range of values between 3 and 10 would be better, but would also be insufficient if only three different pH values were tested in that range.

Students should **not** be told:

- how to collect the data
- how much data to collect.

Data collection and processing

Ideally, students should work on their own when collecting data.

When data collection is carried out in groups, the actual recording and processing of data should be independently undertaken if this criterion is to be assessed. Recording class or group data is only appropriate if the data-sharing method does not suggest a presentation format for the students.

Pooling data from a class is permitted where the students have independently organized and presented their data. For example, they may have placed it on a real or virtual bulletin board. For assessment of aspect 1, students must clearly indicate which data is their own.

Aspect 1: recording raw data

Raw data is the actual data measured. This may include associated qualitative data. It is permissible to convert handwritten raw data into word-processed form. The term "quantitative data" refers to numerical measurements of the variables associated with the investigation. Associated qualitative data are considered to be those observations that would enhance the interpretation of results.

Uncertainties are associated with all raw data and an attempt should always be made to quantify uncertainties. For example, when students say there is an uncertainty in a stopwatch measurement because of reaction time, they must estimate the magnitude of the uncertainty. Within tables of quantitative data, columns should be clearly annotated with a heading, units and an indication of the uncertainty of measurement. The uncertainty need not be the same as the manufacturer's stated precision of the measuring device used. Significant digits in the data and the uncertainty in the data must be consistent. This applies to all measuring devices, for example, digital meters, stopwatches, and so on. The number of significant digits should reflect the precision of the measurement.

There should be no variation in the precision of raw data. For example, the same number of decimal places should be used. For data derived from processing raw data (for example, means), the level of precision should be consistent with that of the raw data.

The recording of the level of precision would be expected from the point where the student takes over the manipulation. For example, students would not be expected to state the level of precision in a solution prepared for them.

Students should **not** be told how to record the raw data. For example, they should not be given a pre-formatted table with columns, headings, units or uncertainties.

Aspect 2: processing raw data

Data processing involves, for example, combining and manipulating raw data to determine the value of a physical quantity (such as adding, subtracting, squaring, dividing), and taking the average of several measurements and transforming data into a form suitable for graphical representation. It might be that the data is already in a form suitable for graphical presentation, for example, distance travelled by woodlice against temperature. If the raw data is represented in this way and a best-fit line graph is drawn, the raw data has been processed. Plotting raw data (without a graph line) does not constitute processing data.

The recording and processing of data may be shown in one table provided they are clearly distinguishable.

Students should **not** be told:

- how to process the data
- what quantities to graph/plot.

Aspect 3: presenting processed data

Students are expected to decide upon a suitable presentation format themselves (for example, spreadsheet, table, graph, chart, flow diagram, and so on). There should be clear, unambiguous headings for calculations, tables or graphs. Graphs need to have appropriate scales, labelled axes with units, and accurately plotted data points with a suitable best-fit line or curve (not a scattergraph with data-point to data-point connecting lines). Students should present the data so that all the stages to the final result can be followed. Inclusion of metric/SI units is expected for final derived quantities, which should be expressed to the correct number of significant figures. The uncertainties associated with the raw data must be taken into account. The treatment of uncertainties in graphical analysis requires the construction of appropriate best-fit lines.

The complete fulfillment of aspect 3 does **not** require students to draw lines of minimum and maximum fit to the data points, to include error bars or to combine errors through root mean squared calculations. Although error bars on data points (for example, standard error) are not expected, they are a perfectly acceptable way of expressing the degree of uncertainty in the data.

In order to fulfill aspect 3 completely, students should include a treatment of uncertainties and errors with their processed data, where relevant.

The treatment of uncertainties should be in accordance with assessment statements 1.1.2, 1.1.3 and 1.1.4 of this guide.

Conclusion and evaluation

Aspect 1: concluding

Analysis may include comparisons of different graphs or descriptions of trends shown in graphs. The explanation should contain observations, trends or patterns revealed by the data.

When measuring an already known and accepted value of a physical quantity, students should draw a conclusion as to their confidence in their result by comparing the experimental value with the textbook or literature value. The literature consulted should be fully referenced.

Aspect 2: evaluating procedure(s)

The design and method of the investigation must be commented upon as well as the quality of the data. The student must not only list the weaknesses but must also appreciate how significant the weaknesses are. Comments about the precision and accuracy of the measurements are relevant here. When evaluating the procedure used, the student should specifically look at the processes, use of equipment and management of time.

Aspect 3: improving the investigation

Suggestions for improvements should be based on the weaknesses and limitations identified in aspect 2. Modifications to the experimental techniques and the data range can be addressed here. The modifications proposed should be realistic and clearly specified. It is not sufficient to state generally that more precise equipment should be used.

Manipulative skills

(This criterion must be assessed summatively.)

Aspect 1: following instructions

Indications of manipulative ability are the amount of assistance required in assembling equipment, the orderliness of carrying out the procedure(s) and the ability to follow the instructions accurately. The adherence to safe working practices should be apparent in all aspects of practical activities.

A wide range of complex tasks should be included in the scheme of work.

Aspect 2: carrying out techniques

It is expected that students will be exposed to a variety of different investigations during the course that enables them to experience a variety of experimental situations.

Aspect 3: working safely

The student's approach to safety during investigations in the laboratory or in the field must be assessed. Nevertheless, the teacher must not put students in situations of unacceptable risk.

The teacher should judge what is acceptable and legal under local regulations and with the facilities available. See the "Safety" section in this guide under "Guidance and authenticity".

Personal skills

Note: The personal skills criterion is assessed in the group 4 project only and is to be found in "The group 4 project" section.

The use of ICT

In accordance with aim 7—that is, to "develop and apply the students' information and communication technology skills in the study of science"—the use of information and communication technology (ICT) is encouraged in practical work throughout the course, whether the investigations are assessed using the IA criteria or otherwise.

Section A: use of ICT in assessment

Data-logging software may be used in experiments/investigations assessed using the IA criteria provided that the following principle is applied.

The student's contribution to the experiment must be evident so that this alone can be assessed by the teacher. This student's contribution can be in the selection of settings used by the data-logging and graphing equipment, or can be demonstrated in subsequent stages of the experiment.

(When data logging is used, raw data is defined as any data produced by software and extracted by the student from tables or graphs to be subsequently processed by the student.)

The following categories of experiments exemplify the application of this principle.

1. Data logging within a narrowly focused task

Data-logging software may be used to perform a traditional experiment in a new way.

Use of data-logging software is appropriate with respect to assessment if the student decides and inputs most of the relevant software settings. For example, an investigation could be set up to monitor a person's breathing capacities while on an exercise bike using a spirometer sensor linked to a calculator-based data logger in which the student controls the level of exercise (speed or workload). Data-logging software that automatically determines the various settings and generates the data tables and graphs would be inappropriate with regard to assessment because the remaining student input required to investigate the breathing capacities would be minimal.

If the experiment is suitable for assessment the following guidelines must be followed for the DCP criterion.

Data collection and processing: aspect 1

Students may present raw data collected using data logging as long as they are responsible for the majority of software settings. The numerical raw data may be presented as a table, or, where a large amount of data has been generated, by graphical means. For example, the student should set the duration and rate of the sampling, and the generated data in the form of lists of measurements from the calculator or computer could be downloaded by the student into a computer spreadsheet. Students must organize the data correctly, for example, by means of table or graph titles, columns or graph axes labelled with units, indications of uncertainties, associated qualitative observations, and so on.

The number of decimal places used in recorded data should not exceed that expressed by the sensitivity of the instrument used. In the case of electronic probes used in data logging, students will be expected to record the sensitivity of the instrument.

Data collection and processing: aspects 2 and 3

Use of software for graph drawing is appropriate as long as the student is responsible for most of the decisions, such as:

- what to graph
- selection of quantities for axes
- appropriate units
- graph title
- appropriate scale
- how to graph, for example, linear graph line and not scatter.

> Note: A computer-calculated gradient is acceptable.

In the example of the investigation to monitor breathing capacities, the student could process data by drawing a graph in the spreadsheet and measuring the breathing frequency from the data. By inspecting the graph or spreadsheet data, the maximal and minimal lung volume values could be identified and used to calculate the mean tidal volume at rest. The mean volume of air breathed per minute and recovery rate after exercise could also be calculated.

Statistical analysis carried out using calculators or calculations using spreadsheets are acceptable provided that the student selects the data to be processed and chooses the method of processing. In both cases, the student must show one example in the written text. For example, the student must quote the formula used by or entered into a calculator and define the terms used, or the student must write the formula used in a spreadsheet if it is not a standard part of the program's menu of functions (for example, mean, standard deviation).

2. Data logging in an open-ended investigation

Data-logging software can enhance data collection and transform the sort of investigations possible. In this case fully automated data-logging software is appropriate with regard to assessment **if** it is used to enable a broader, complex investigation to be undertaken where students can develop a range of responses involving independent decision-making.

For example, a task could be set to investigate a factor that affects the rate of photosynthesis. If an oxygen sensor with automatic pre-programmed software to monitor the amount of oxygen released by an aquatic plant is used, the student could use the program to develop a broader, complex investigation, for example, comparing rate of photosynthesis in different species of aquatic plants at different light intensities.

Design: aspect 1

The student must state a focused problem/research question, for example: "What is the difference in the rate of photosynthesis at different light intensities, as measured by oxygen release, between Elodea canadensis and Myriophyllum spicatum?"

Relevant variables must also be identified, for example:

- independent variable—species of aquatic plants
- dependent variable—rate of oxygen production
- controlled variables—temperature, mass of plant, leaf surface area, time, light quality (wavelength).

Design: aspect 2

The student must design a method to monitor and control the variables (for example, a water bath for control of temperature), use an electronic balance to determine the mass of the plants, and use the same light source to control light quality.

Design: aspect 3

The student must design the method for the appropriate collection of sufficient raw data. The student would select the species of aquatic plants to use, and measure the amount of dissolved oxygen in the water using the oxygen sensor program. The student would also decide on the range and number of different light intensities and the number of experimental replicates.

Data collection and processing: aspect 1

Appropriate raw data would consist of the rates of photosynthesis derived from the graphs of the experimental runs generated by the program using the oxygen sensor. These rates of photosynthesis may be calculated by the student using a function on the program that analyses the graphs. This must be done without prompting by the teacher. The derived data for rates of photosynthesis could be annotated on a series of graphs or presented in a table with an appropriate title, column headings and units. Calculation of uncertainties would not be expected in this experiment. In addition, other important data should be recorded, for example, water temperature.

Data collection and processing: aspect 2

The graphs showing changes in oxygen concentration would not be assessed, as these would have been generated automatically by the pre-programmed software on the data logger, without input from the student. However, the rates of photosynthesis derived from these graphs could be plotted against light intensity for each species using graph-plotting software where student input is possible, for example, choice of type of graph, x and y axes, range and scale.

Data collection and processing: aspect 3

The student would generate graphs of light intensity versus rates of photosynthesis for each species, which should have clear titles, correctly labelled axes, a legend for the data of the different species of plants, and trend lines to reveal the degree of uncertainty.

Section B: use of ICT in non-assessed practical work

It is not necessary to use ICT in assessed investigations but, in order to carry out aim 7 in practice, students will be required to use each of the following software applications at least once during the course.

- Data logging in an experiment
- Software for graph plotting
- A spreadsheet for data processing
- A database
- Computer modelling/simulation

There are many examples of the above in the ICT resources for biology, chemistry and physics on the OCC.

Apart from sensors for data logging, all the other components involve software that is free and readily available on the Internet. As students only need to use data-logging software and sensors once in the course, class sets are not required.

The use of each of the above five ICT applications by students would be authenticated by means of entries in the students' practical scheme of work, form 4/PSOW. For example, if a student used a spreadsheet in an investigation, this should be recorded on form 4/PSOW. Any other applications of ICT can also be recorded on form 4/PSOW.

